CONF-9510328--1

DOE/MC/28060-96/C0637

Landslide Remediation on Ohio State Route 83 Using Clean Coal Combustion By-Products

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RECEIVED
FEB 2 1 1996
OSTI

Contractor:

Dravo Lime Company
3600 Neville Road
Pittsburgh, Pennsylvania 15225

Contract Number:

DE-FC21-91MC28060

Conference Title:

University of Kentucky Ash Utilization Conference

Conference Location:

Lexington, Kentucky

Conference Dates:

October 23-25, 1995

Conference Sponsor:

University of Kentucky, & U.S. Department of Energy, Pergomon Pr

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ABSTRACT

The disposal of flue gas desulfurization (FGD) by-products has become a major concern as issues of emission cleansing and landfill costs continue to rise. Laboratory tests conducted at The Ohio State University have shown that dry FGD by-products possess certain engineering properties that have been proven desirable in a number of construction uses. As a follow on to the laboratory program, a field investigation into engineering uses of dry FGD wastes was initiated. In the present work, an FGD by-product was used to reconstruct the failed portion of a highway embankment. The construction process and the stability of the repaired embankment are examined.

State Route 83 in Cumberland, Ohio has been damaged by a slow moving slide which has forced the Ohio Department of Transportation to repair the roadway several times. In the most recent repair FGD by-products obtained from American Electric Power's Tidd PFBC plant were used to construct a wall through the failure plane to prevent further slippage. In order to evaluate the utility of using coal combustion by-products in this type of highway project the site was divided into three test sections. In the first repair section, natural soil removed from the slide area was recompacted and replaced according to standard ODOT construction practices. In the second section the natural soil was field mixed with the Tidd PFBC ash in approximately equal proportions. The third section was all Tidd ash. The three test sections were capped by a layer of compacted Tidd ash or crushed stone to provide a wearing surface to allow ODOT to open the roadway before applying a permanent asphalt surface.

Measurement of slope movement as well as water levels and quality have begun at the site in order to evaluate long term project performance. The completion of this project should lead to increased acceptance of FGD materials in construction projects. Monetary savings will be realized in avoiding some of the disposal costs for the waste, as well as in the reduced reliance on alternative engineering materials.

INTRODUCTION

The combustion of coal containing sulfur in U.S. power plants is thought to be one of the principal causes of acid rain in North America. The Clean Air Act of 1970 was passed in an attempt to reduce the environmental threat from sulfur released into the atmosphere. In addition to other standards, this law established a permissible level for emissions of sulfur dioxide (SO_2) from coal fired power plants. Amendments in 1977 and in 1990 to the Act have strengthened its provisions with respect to the allowable levels of atmospheric SO_2. Subsequently, many power plants have opted to install desulfurization systems. Typically, these systems work by injecting a reagent that combines with the sulfur to form a solid compound which is collected prior to the atmospheric release of the exhaust gas (Bigham et al., 1992). The solid waste product must then be disposed of in an approved manner.

FIELD DEMONSTRATION PROJECT - OHIO STATE ROUTE 83

Site History. Ohio State Route 83 runs approximately north to south for nearly the entire length of the state. Central Ohio Coal operates an active strip mine in the area and the section of the highway studied carries a large number of loaded coal hauling tractor trailers. The portion that failed is an embankment about 15 meters high and 1000 meters long located just south of Cumberland, and has, according to area residents, caused problems for local traffic for 25 years. In the past five years, state crews have had to patch the pavement two to three times a year. In the late spring of 1993, a site inspection identified a one to two inch vertical offset along the centerline. An investigation of the slope revealed a hummocky terrain indicative of land slippage.

Embankment Repair. The repair of the failed section was completed in three stages. The initial stage consisted of the excavation of the embankment and removal of the failed material. Approximately 11000 yd^3 totaling eight to ten feet of embankment material were excavated in late October, 1994. Because the failure plane was not encountered, an additional trench on the upslope side of the roadway was excavated. The trench was backfilled with compacted FGD ash to form a key that a slope stability analysis indicated would provide an adequate factor of safety against sliding. Upon completion of the trench, drain lines and fabric drain boards were installed to keep groundwater out of the ash. The key was placed in 12 to 18 inch lifts, spread using a small bulldozer, and rolled with a single drum sheepsfoot roller. The remainder of the embankment was then divided into four separate sections. At both the north and south ends of the repair, control sections consisting of recompacted natural soil were constructed. These two sections were placed in accordance with standard ODOT construction procedures. Between the two control sections, a third test section consisted of a mix of FGD ash and natural soil. A final section of only FGD ash was also constructed. The FGD/soil mixture was to be placed as close to 50% soil, 50% ash as field mixing conditions would allow. The section was built up in lifts of 8 inches of the soil/ash mix. Compaction was achieved with the same equipment as had been used in the soil sections. The Tidd ash section was constructed in lifts of from 12 to 24 inches which were watered to get close to optimum conditions, and then compacted using the roller. The compacted water contents of the soil, ash, and ash and soil mix were 19%, 18% and 15% respectively. Typical compaction was about 95% of Standard Proctor in the four sections. Work on the embankment was finished on December 14, 1994. Since this date was past the last date to pave the rebuilt highway, an 18 inch layer of compacted FGD by-product was used as a temporary wearing surface over half the site. The other half of the roadway was treated using the macadam surface typically specified by ODOT for temporary repairs. This repair consisted of 18 inches of stone ranging in size from 1.5 inches to 0.19 inches. The road was opened to traffic in December, 1994. In April, 1995, ODOT installed slope inclinometers in the test section. Monitoring slope movement and collection of water samples is continuing. We expect to continue to monitoring of the slope over the next three years.

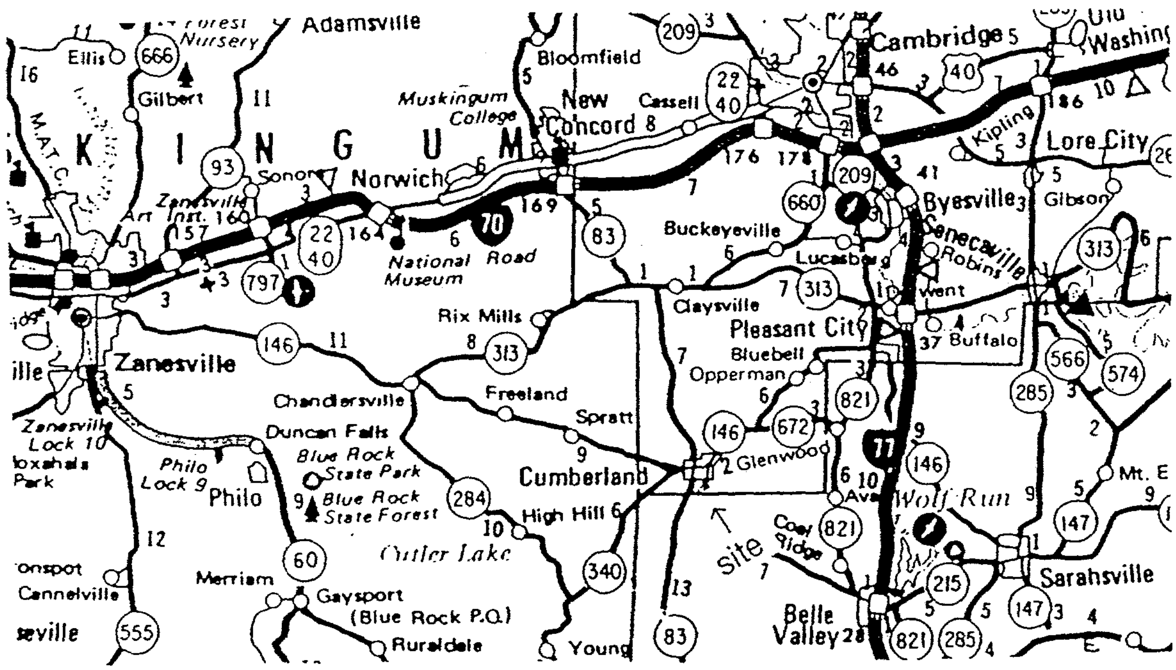

Figure 1. SR 83 site map

ANALYSIS

Stability analyses of the three different reconstruction configurations were performed using the slope stability program PCSTABL (Lovell, 1988). The locations of structural features as determined in the borings and verified during the construction were included in the computer models of the three sections. Figure 2 shows the critical surface and calculated factor of safety for the soil only sections. The presence of the FGD key has forced the potential failure surface away from the hillside with the result that the most likely failure is fairly shallow but still is one with a low safety factor that may involve the highway. Figure 3 shows the analysis conducted on the FGD-soil repair. The strength properties used were measured on laboratory prepared FGD-soil samples. Note that for this case the critical failure surface would pass through the FGD-soil mix but the lowest factor of safety is 19 indicating a very low probability of failure. Figure 4 presents the

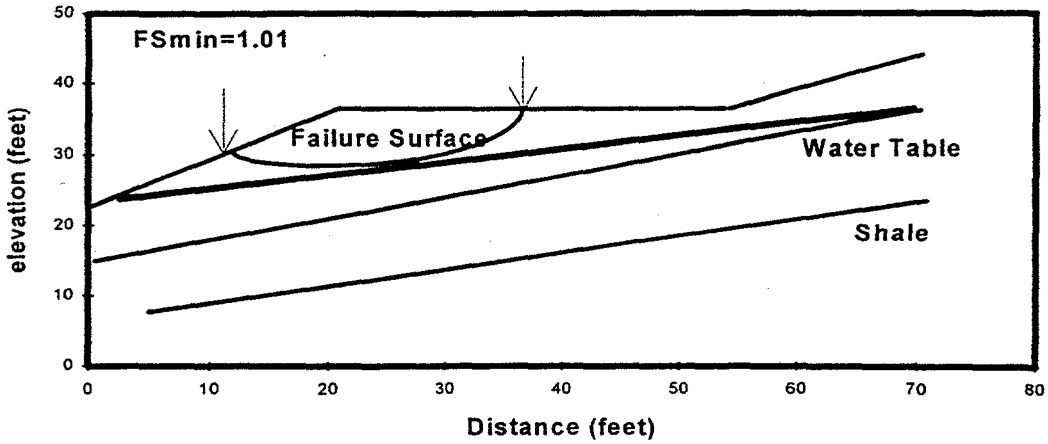

Figure 2 Failure surface in soil only

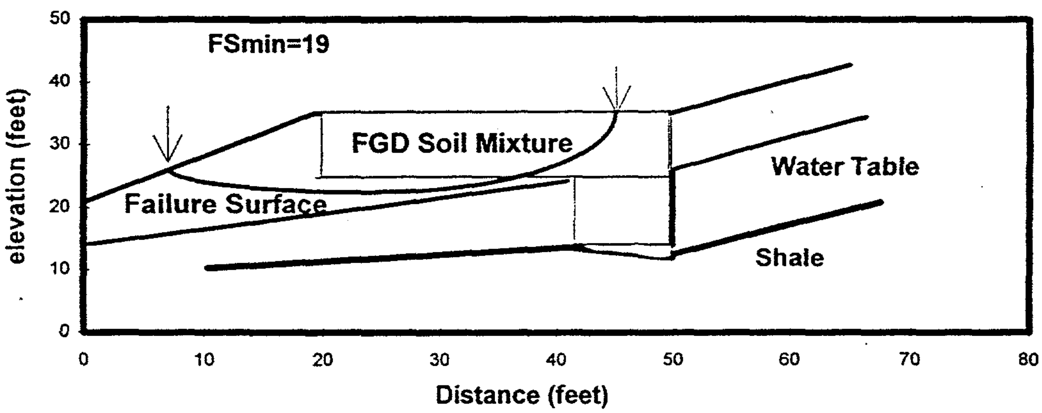

Figure 3. Failure surface in FGD / soil mixture

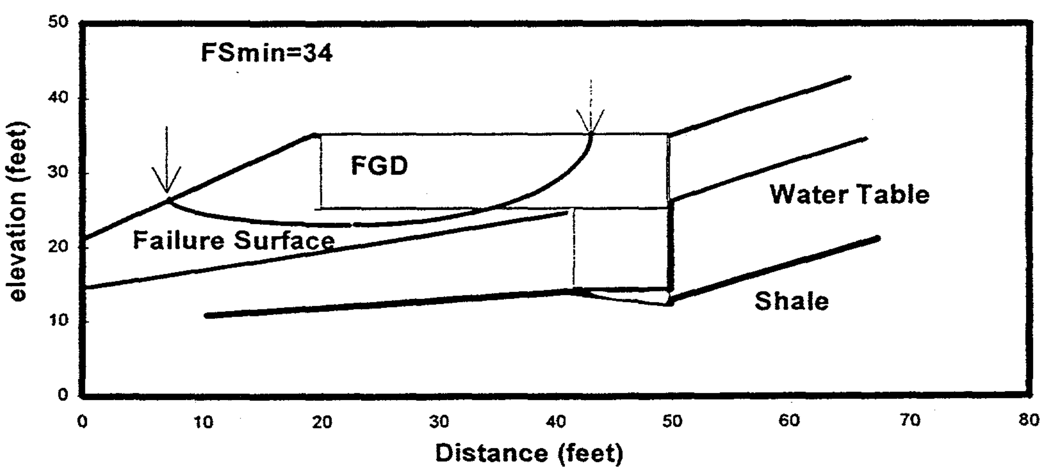

Figure 4 Failure surface in FGD

results of the stability computations for the FGD only section. As in the case of the FGD-soil mixture, the critical failure surface passes through the FGD. Also, as was found with the mixture, the minimum Factor of Safety is very high, in this case in excess of 33. It is clear that the use of FGD or FGD modified soil can significantly improve the safety and stability of hillside construction of the type found on Ohio SR 83.

SUMMARY AND CONCLUSIONS

It has been shown how one dry FGD by-product can be successfully incorporated into a highway construction program. In this project a PFBC by-product demonstrated high strength, ease of installation and, to date, no significant change in the environment of the surroundings. The installation procedures that were followed make it clear that no special equipment or training is necessary to use the by-product. The performance of the FGD material during construction makes it clear that the level of care required on any construction project should be adequate when working with this material. Further, its excellent strength properties and workability are suited for field modifications.

ACKNOWLEDGMENTS

The demonstration project described in this paper forms part of the project titled "Land Application Uses of Dry FGD By-Product", being performed in the Civil Engineering Department at The Ohio State University. The contract sponsor is Dravo Lime Company. Principal funding has been provided by the Ohio Coal Development Office, Columbus, Ohio and the U.S. Department of Energy, Morgantown Energy Technology Center, Morgantown, West Virginia. ODOT paid the cost of construction on SR83. We are particularly grateful for the help provided by Mr. Harold Neuhart of ODOT District 5, Special Projects Branch. Additional funding has been provided by Dravo Lime Co., American Electric Power and Ohio Edison.

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